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SUSPENSION FUELS. ONE TYPE OF HOPEFUL HIGH ENERGY FUEL

by

Wang Chu Fa

FOREIGN TECHNOLOGY DIVISION

EDITED TRANSLATION

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SUSPENSION FIELD. ONE TYPE OF HOPEFUL HIGH ENERGY FUEL

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TABLE OF CONTENTS

- the new turbines of raised (Fahrenheit) temperature of several hundred degrees. At this time , the original combustion chambers had to work under super-warm conditions, until in 1968 when they changed to a new combustion chamber. In this way, the earliest combustion generators completely changed shape thereby entering into a new era .

The combustion generator, in terms of design characteristics is indeed not as one might wish, yet it is not reckless either . One must base on the future requirements, the conjectured future requirements of the engines' approximate type, thrust (or output), weight class, flight requirements, and including any other technolo -gical demands, rely equally on the above for the design of the combustion generator .

In order to research and construct different thrust (or output -) classes of engines, one may take the combustion generator and manufacture it appropriately enlarged or reduced (in size) . But there are definite limits to enlarging or reducing it's proportions. Especially when speaking of small engines, for they posess special characteristics in terms of their design and manufacture . For example, small engines ordinarily adopt " Axial flow + Centrifugal" type air compressors, and reflux combustors . For this reason it is necessary to research and construct special small engine combustion generators . At present there are several nations in the midst of

- making several small engine combustion generators . Their air flow capacity is only 5 to 2.5 Kg./sec. . It is important they be designed with the focus on the future requirements of 200 to 800 H.P. small turbo-axial engines .

Based on the concrete situation, the appropriate employment of combustion generators will be a definite help to the research and construction work of small engines . But, one is also not able to regard it as a panacea . Firstly, the combustion generator itself must follow the improvements of the component technologies thus constantly develop and constantly adopt new techniques . Secondly, the design of the combustion generator should have a definite aimness and should, under the conditions of the changing technological demands of future engines, thus change . Finally, from the combustion generator's transitional period till the time of the engine's research and construction it is required it be manufactured appropr-iately enlarged or reduced . Then one may add and install the other necessary components . Moreover, at times, one may make use of the complete combustion generator, and other times in which one only uses the key technology . But there is one point worth paying attention to , that is, before the engines research and constructio-n work is totally arranged, besides making a good study of the main

- points of the component technologies, one also should study the matching workings between these components . In this way only then will the engine's research and construction have a solid and reliable foundation .

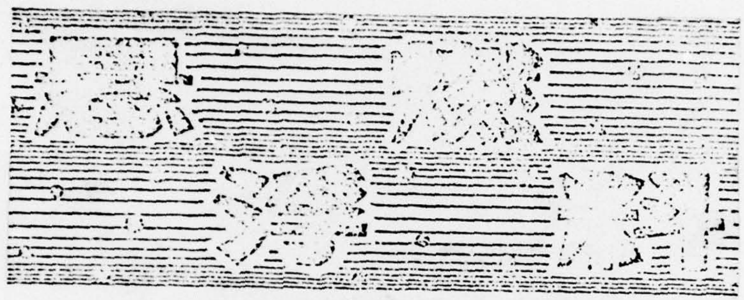
Being lightweight is a special demand of aviation technology . The aircraft's structure demands being lightweight . The fuel occup -ies a fairly large ratio of an aircraft's take off load, approx. consituting 20 to 50% . The farther the flying range the greater the specific gravity (mass) occupied by the fuel . The fuel in interceptor and fighter aircraft occupies approx. 20 to 30% of the take off load . The fuel in strategic bombers and large type passe -nger aircraft occupies 40 to 50% of the take off load . Men are racking their brains from every aspect for ways to lighten aircraft and engine weight . Searching for high energy fuels, raising the fuel's heat value is one important direction .

The engines thrust is dependent upon the fuel undergoing a change by burning and thus releasing heat energy . If one is able to raise the quantity of heat produced by every Kg. of fuel then one may greatly improve the aircraft's flying characteristics . Under identical take off loads and speeds, one may increase the air -craft's range, or under identical flight speeds and ranges, one may

- increase the aircraft's effective load . ...

A measure of the fuel's energy property's characteristics is called the heat value, the quantity of heat produced by burning 1 Kg. of fuel is called the heat value/mass, the unit of measure is a Calorie/Kg. . The heat value produced by burning 1 Liter of fuel is called the heat value/volume , the unit of measure is Calories/L -iter . At present, every nation of the world extensively produces and uses aircraft fuels . Although there are many specifications and varieties, however, the majority of aviation kerosene type fuels are refined from petroleum . They are also called hydrocarbon class fuels (or carbonized compound fuels) . Although there are many differences in the physical-chemical properties of these fuels, and their work requirements are not the same, however, looking from the angle of their energy properties the differences indeed aren't that great . In general the difference in the heat value/mass doesn't exceed 3%, and there is only approx. a 10% difference in the heat value/volume . For this reason, in the course of jet technology for the sake of causing the engine to obtain greater thrust, and increase the aircraft's range; men up to now have been studying new types of fuels whose energies greatly exceed the aviation kerosene type .

They are commonly called high energy fuels, there are many types of high energy fuels suspension fuels are one type among them . It is one type of hopeful high energy fuel .



——一种有希望的高能燃料

王祖法

SUSPENSION FUELS

One type of hopeful high energy fuel

Wang Zu Fa

What are suspension fuels?

By taking dense and relatively small light metals(like Mg,Al,etc.) or B (Boron) powder, and blend them into aviation kerosene or other hydrocarbon type fuels to form a type of evenly (blended), stable yet flowable viscous liquid, which thereby raises the avaition ker-osene's energy characteristics . Because the metal powder takes up existing in a suspended state, therefore it is called a suspension fuel .

The earliest considered light metals were Aluminum, Magnesium, Beryllium, Lithium, and in addition there was Boron . Aluminum and Magnesium's heat value/volume is higher than that of aviation kerosene , but it's heat value/mass is slightly lower. Beryllium and Boron's heat value/mass and heat value/volume are both higher than that of aviation kerosene . As for Lithium, it's energy characteristics aren't outstanding enough, and although Beryllium's energy is high, but it's sources are few moreover, it's toxicity is very great . Therefore , it was the first to be eliminated. Afterwards, the point of emphasis of the research turned to the study of Al, Mg, and B . In comparison with aviation kerosene, Al, Mg, and B have still another special characteristic , namely that the oxygen (or air) they need to burn completely is a good deal less (than that of aviation kerosene) . Therefore when burning they are able to produce high temperatures . Regardless whether it is according to chemical calculations, or based on the results of actual tests, when they are being burned the heat value and thrust that is produced in the consumption of every Kg. of air is higher than that of aviation kerosene .

How are suspension fuels made?

As superfine pwder the density differences of Al, Mg, and B are 2.70, 1.47, and 2.30 respectively . The unit of measure is the gm/cm^2 . They are a good deal higher (in density) than aviation kero -sene (approx. 0.8 gm/cm^2) . If one wants to cause their powder to be able to remain suspended in the aviation kerosene without sinking for long periods of time, the powder must be of extremely fine grain size . A great amount of experimental work proves the diameter of the granules should be below 1 to 2 microns, for only then is one able to satisfy the demands of making and preparing suspension fuels. If one wants to produce this kind of fine powder it won't do to use ordinary methods . Already many methods have been found to produce these superfine powders . For example, the Mg powder used in the mak -ing and preparation of Mg suspension fuel may adopt atomized Mg powder whose diameter is 1.5 microns or, the vacuum vaporized Mg pow -der whose average diameter is less than 1 micron . There is yet another type of vapor-condensation method to produce Mg powder, it's approx. average diameter is only 0.2 microns . The powder used in making and preparing B suspension fuel may be obtained from Mg deoxidizing Boron oxide . The grain size is between 0.6 to 1.4 mic -rons . One may also use electro-chemical methods to produce B powd -er, their average diameter is less than 1 micron . If one produces Al powder, then there is a type of method in which one may obtain an even finer grain size .

This type of method causes Aluminum to directly disperse in aviation kerosene . Briefly, it's process is to take aviation kero -sene and pour it into the channels between a region of two electro -plates then add Al pellets of 50mm in diameter into the channels . One then applies electricity between the two poles which is equally triggered between the metal pellets, also producing the electric discharge phenomenon . In this way one may continually portion out granules from the metal pellets of unequal sizes, 0.001 to 1 micron which disperse evenly in aviation kerosene .

The suitable additive agent

By taking superfine Mg, Al or B powder(occupies 40to60% of the suspension fluids' total mass) and mixing with aviation kerosene one is only able to produce a type of immobile paste , which is very difficult to be transported and atomized in the pipelines . In order to cause the suspension fuel to obtain good mobility and atomization one must add in the proper additive agent . This class of additive agents belong to what is refered to in chemical terms as surface activator chemical compounds . After adding into the suspension fuel a small quantity (in general constituting approx. 1%) of the surface activator it (the fuel) then contains the special features of being glossy and smooth .

Different metal powders and different methods of producing powders demands selecting and using surface activators of different constructions . As to the selection of a surface activator, the type of aviation kerosene has a definite influence on it . For this reason the final selection of a surface activator depends for the most part upon a great amount of experimental work . The function of the surface activator is to hasten dispersion and moistening, and to promote the reciprocal functioning between the powder and the aviation kerosene ; thereby being able to cause the suspension fuels form to change even and stably . Based on a study of each type of surface activator the better surface activators are those that are regarded as oil soluble chemical compounds . Their molecular structure should contain a hydroxyl together with an ester base or a metallic salt and a polyethylene group .

Brief production techniques

Once one has the superfine metallic powder and the proper additive agent, the producing of suspension fuel is relatively simple . Ordinarily, carrying out the mixing under set temperature conditions and using mechanical mixing methods one is able to get an evenly blended suspension liquid . If one then takes it after passing through a colloid grinding and proceeds to grind it further, then one will obtain a suspension liquid that is even more evenly blended,

- stable, and moreover it's mobility and atomizing characteri -stics will also gain very great improvements .

Special characteristics of several types of suspension fuels

After suspension fuels had passed through a great quantity of ground and flight testing it was discovered that Al suspension fuel had a very big weak point . Namely that after burning the melting point of the created oxides is relatively lower . Under the combustion chamber's operating temperature requirements Al oxide is in a molten state which could destroy the regular operation of the combustion chamber . For this reason the research work on Al suspension fuel was quickly abandoned . The good qualities of Mg suspension fuel are comparatively many; the thrust produced by burning it with each Kg. of air is comparatively high , it ignites and burns easily . Under conditions where aviation kerosene is not able to burn, it is able to operate regularly . It's combustion rate is faster than that of aviation kerosene , therefore for this reason one may reduce the dimensions of the combustion chamber. The com -bustion efficiency and the flame out speed are both higher than aviational kerosene . It is able to burn completely within a wide range of surplus air co-efficients , this causes the energy (of the fuel) to be fully utilized

The combustion products of the Mg oxide are unusual -ly loose and soft, and are very easily blown away by the burning gases but it has very little effect on the combustion system . Mg suspension fuel may raise the engines thrust greatly . The suspensio -n fuel that contains 60% Mg powder is able to raise the thrust close to 70% . At the same time, if one adopts the proper (water) spray cooling . measures the thrust can be doubled . The heat value/mass for Mg suspension fuel is low and it is not able to significantly increase the flying range . It is suitable for use in short range, high speed aircraft, and is best used in high compression engines or suitable for use inside the after-burner chamber of gas turbo -jet engines .

The best quality of B suspension fuel is it's high heat value but as for combustion efficiency and other combustion characteristics they are not only less than those of Mg suspension fuel, moreover, they are not even as good as aviational kerosene . Besides this, B suspension fuel can also form large quantities of Boron oxide sedi -ments which will seriously affect the regular operation of the engine . For the sake of overcoming these weak points of Boron suspensi -on fuel, they developed through research a brand new and effective

- solution, which namely is to add thermal additive agents and chemical additive agents into B suspension fuel . The thermal addit -ive agent is Mg powder . It is able to raise the igniting and combustion characteristics of B suspension fuel . The chemical addi -tive agent is Lithium Fluoride, it can aid in the removal of the Boron oxide "obstacle" . This type of new Boron suspension fuel that contains small quantities of Mg powder and Lithium Fluoride additive agents is a type of very hopeful and promising high energy fuel .

Existent problems

A great amount of test work proves that suspension fuels may be used in engines that at present are in widespread use , without making any fundamental changes (in them) . However there still exist several problems that are not easily solved, i.e. (fuel) transport and atomization is comparatively difficult , because it is a sticky and dense liquid . Therefore after after it flows through the pipelines and nozzles it will leave behind a layer of adherent matter

. Under the conditions of the surrounding temperature being higher, a portion of the liquid in the fuel will evaporate and then leave behind a solid metal powder covering . After the fuel passes through **several** times the places in th nozzles and pipelines where sections are relatively small are very easily blocked up . This is an important reason that prevents high energy suspension fuels from actual use . Mankind always continuously progresses by (in) emerging victorious over difficulties . The problems in the development of suspension fuels will be solved in the long run .

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